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in Buyer-Seller Communication?

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Abstract

We compare two types of costless communication, Cheap Talk and Information Disclosure, in a buyer-seller interaction where the buyer has private information about his ideal location in the product space and the seller is entitled to make a take-it-or-leave-it offer comprising a product location and a price. We show that Cheap Talk can overcome Information Disclosure in terms of seller's payoff and, generally, welfare. Under Information Disclosure, the buyer garbles the signal compared to the one in a Cheap Talk equilibrium to persuade a lower price which inevitably reduces profits. However, Information Disclosure may also reduce product attractiveness and, thus, welfare.

Keywords: cheap talk, disclosure, incomplete contracts, strategic communication.

1 Introduction

Ann is a designer of personalized products (e.g., apparel designer or architect) and she is about to design a product to Bob. Designing a product that fits with the Bob's ideal one, Ann increases his willingness to pay for her design. Consequently, matching Bob's preferences she can charge a higher price. However, Bob's preferences are private information and, anticipating Ann's incentives to increase the price, he may be strategic when communicating them (even at the cost of reducing product attractiveness). In an informal meeting, Bob may talk vaguely to persuade her to lower the price. If a big set of pictures and certifications (e.g., hard information) were available, Bob would also disclose them strategically (e.g., reveal/conceal). Anticipating that there always exists a strategic behaviour, What is the best communication environment Ann should use to learn about Bob's preferences? Would Ann prefer that Bob shows certifications selectively about his

habits/preferences or would she rather prefer to have an informal meeting with him? Can informal meetings where messages are unverifiable overcome a bunch of verifiable certifications that may be disclosed selectively? Formally, we are interested to know whether Strategic Information Transmission (or *Cheap Talk* - CT) can be superior to Strategic Information Disclosure (ID) in terms of Ann profits and welfare. Could Ann strictly prefer one of them? We prove that CT overcomes ID in terms of Ann profits and, likely, welfare. This, maybe striking, result suggests that Ann may prefer CT over ID.

To answer these questions, we study a buyer-seller interaction where a buyer (Bob) has private information about his ideal location in the product space and the seller (Ann) is entitled to make a take-it-or-leave-it offer. The buyer is allowed to provide information about his preferred location to the seller. After receiving a message, the seller with zero production and location costs makes a take-it-or-leave-it offer comprising a product location and a price. The communication structure to persuade the seller can be either Strategic Information Transmission (also known as *Cheap Talk* -CT) (Crawford and Sobel, 1982) or Strategic Information Disclosure (ID) (Kamenica and Gentzkow, 2011; Rayo and Segal, 2010). We compare them and we discuss which communication environment would be preferred by the seller.

Additional to the buyer-seller interaction, there are other cases where comparing these strategic communication environments is relevant. For instance, consider the case of an on-line ad platform (e.g., facebook) that offers ad slots with different consumers profiles to advertisers.¹ Matching the advertiser's market (consumers) target increases the advertiser's willingness to pay and platform profits. The market target is private information and advertisers have incentives to communicate strategically with the platform. The question of whether informal meetings or requiring certifications generates higher profits for the on-line platform may be crucial in this strategic communication. Alternatively, a bank may need information about borrower's financial behaviour or investment projects in order to design the best financial contract. The bank may require financial credentials, scores, and credit history or the bank may base his decision on informal communication.² Even when this financial case may be modelled as vertically differentiated market, studying what communication environment dominates is very important for the bank.

Independent of the communication structure the buyer faces a simple trade-off. On one hand, disclosing accurate information about his preferences allows the seller to choose a product location that is closer to the buyer's ideal one. On the other hand, it prompts the seller to charge a higher price as the product meets the buyer's preferences. Consequently,

¹The strategy of eliciting consumer information and, thus, preferences from their typing (searches and emails) has been recorded by the news. For example, see The Guardian, August 15th 2013 "Google: don't expect privacy when sending to Gmail".

²Historically in the U.S., small business has mainly relied on informal meetings with local banks and lenders as the communication device to learn about investment projects (Petersen and Rajan, 2002).

communicating imperfectly his ideal location in the product space, the buyer finds a balance between price and product attractiveness.

We first characterize the CT equilibria and then we compare them with the one under ID. As it is usual in CT communication, an equilibrium requires that players satisfy the incentive constraints to tell the truth and make actions that are consistent with players beliefs (using Bayes rule). In spite of these constraints that limit the informativeness of messages, an (informative) CT equilibrium allows the buyer and seller to avoid those situations where there is no trade, improving welfare.³ As it is common in the literature on Cheap talk, there is multiplicity of equilibria differing on the signal's informativeness (number of partitions), buyer's and seller's expected payoffs, and welfare loss. In every informative equilibrium, there is trade with probability one and an inefficiency arises when the product location does not coincide with the buyer's ideal.⁴

Information Disclosure provides verifiability (and commitment) in buyer's signal, allowing the buyer to choose among a much richer set of signal distributions. Actually, the set of distributions that can be part of an equilibrium under CT is a subset of the set of feasible distributions under ID. Consequently, the buyer is better off under ID. Additionally, for any CT equilibrium there are superior signals distributions under ID. However, it is not clear whether the buyer chooses a signal distribution that improves both players' payoff and welfare upon a CT equilibrium. Actually, we prove that under the ID, the buyer strategically persuades the seller to reduce the price in comparison to the price in any informative CT equilibria. The buyer achieves this better deal by garbling the signal distribution which may reduce product attractiveness and welfare. Consequently, CT results to be superior than ID in terms of seller surplus and welfare.

Our main contributions are to find a communication setup where it is possible to compare both communication structures and to prove that Cheap Talk may be superior to other communication structures in terms of seller surplus (receiver) and welfare. Since the seminal paper of Crawford and Sobel (1982), a vast literature has grown assuming ad-hoc Strategic Information Transmission (or Cheap-Talk), as a natural communication framework when contracts are incomplete. Disclosure has also been extensively analyzed and, recently, several papers has pointed out its power for strategic persuasion (Milgrom, 1981).⁵ However, the literature has always focused on Disclosure and Cheap Talk sepa-

³Informative communication means all but pure babbling. A babbling equilibrium is defined by a completely noisy communication where no information is transmitted, which is equivalent to no communication.

⁴There are two exceptions: First, in a babbling equilibrium there may be no trade. Second, there also exists a perfect informative equilibrium where there is no welfare loss. However, these equilibria are not plausible because the babbling equilibrium is Pareto dominated by other equilibria and the perfect informative equilibrium would not survive as the buyer prefers not to talk instead of revealing his preferences.

⁵Disclosure a la Milgrom assume that agents with different vertically differentiated types having access

rately.⁶ This gap may be based probably on the higher costs associated with Disclosure or on the seemingly strict dominance of Disclosure in comparison to Cheap Talk. Our paper fills this gap proving that indeed Cheap Talk may be superior to Disclosure, even in the absence of such costs.

We also contribute to the literature on buyer-seller communication with asymmetric information. The case where the seller has more information and makes recommendations to a buyer has been analyzed in a Cheap Talk environment (Inderst and Ottaviani, 2013) and in a Persuasion and Disclosure setup (Milgrom, 2008; Kamenica and Gentzkow, 2011). We focus here on the case where the buyer has superior information about his own preferences and the seller has the bargaining power.⁷ In this sense our article is closer to Sher and Vohra (2011) which address the communication problem when the buyer has private information and the seller the bargaining power. In their setup, the seller uses rounds of Cheap Talk communication (from buyer to seller) as a price discrimination device. We contribute to the literature by analyzing the optimality of the communication structure in a buyer-seller interaction.

Finally, our framework can also be used to model alternative interactions. For instance, the literature on authority versus communication in organizational design (Dessein, 2002; Alonso and Matouschek, 2008; Goltsman, Hörner, Pavlov, and Squintani, 2009) analyzes situations where an agent is better informed about the state of world and a principal has the bargaining power to choose between delegating the decision right to the agent and communicating with the agent to make a decision himself. This literature assumes Cheap Talk as the communication device since it focuses on those organizational interactions where decision making and communication take place in a complex, fast, and dynamic environment. Thus, Cheap Talk provides a good fit to represent them, specially for interactions within lower levels in the organization. However, when important strategic decisions in higher levels are involved, the CEO may require hard information to base an important strategic decision (e.g., studies of market demand, consultancy, etc.). In such a case the CEO may choose between strategic disclosure as an alternative to Cheap Talk.⁸

to different set of verifiable signals. Consequently the disclosure procedure relies on the unraveling argument that generates the following fulfilled beliefs: the type who does not disclose himself is assumed to be the lowest type. However this argument does not apply in our model as we consider a horizontally differentiated model.

⁶See Sobel (2010) for a survey with applications on CT and ID.

⁷Our results also hold in those situations where communication may disclose information, even when neither the buyer nor the seller know buyer's preferences. For instance, an architect may learn buyer's preferences asking questions about buyer's habits even if the buyer does not really know his preferences about designs until he sees it (but he is aware of the role of communication).

⁸Our model fits these environments. For instance, a local manager with private information about market conditions proposes a project to the CEO who has the power of defining a strategy and the budget to implement it. The cost to implement the project depends on how well the strategy fits with market conditions. The local manager utility increases with budget and decreases with the project cost; the CEO

Consequently, further research may be encouraged to analyze the optimal communication structure when defining the organizational design.

2 Model

A buyer would like to acquire a unit of a good that comes in different varieties. He has private information about his ideal variety θ and there is a common prior that $\theta \sim U[0, 2]$. The utility derived from consuming a product with variety $x \in [0, 2]$ and price $p \in \mathbb{R}_+$ is

$$U(p, x; \theta) := 1 - \|x, \theta\| - p, \quad (1)$$

where $\|x, \theta\| := \min\{|x - \theta|, 2 - |x - \theta|\} \leq 1$ represents a linear transportation cost.⁹ Notice that, for a given price, a product with variety $x = 2$ provides the same utility to the buyer than a product with variety $x = 0$. Consequently, our setup represents a circular model as in Salop (1979).¹⁰ On the supply side, a seller with zero production and location costs is entitled to make a take-it-or-leave-it offer comprising a price and a product location, i.e., (p, x) . If the offer (p, x) is accepted, seller payoff is $\Pi = p$. Both the seller and the buyer are risk neutral and have zero outside options.

We allow the buyer to communicate with the seller providing a signal s . The message space equals the location space, i.e., $s \in [0, 2]$. We compare two possible ways of costless communication: 1) Strategic Information Transmission (or *Cheap Talk*, CT) where any non-verifiable and non-contractible signal can be sent as in Crawford and Sobel (1982); and 2) Strategic Information Disclosure (ID) where the buyer announces and commits to a verifiable but non-contractible signal distribution F as in Kamenica and Gentzkow (2011).

The timing in each communication structure is as follows: The buyer privately observes θ and sends a signal s drawn from a distribution $F : [0, 2] \rightarrow [0, 1]$.¹¹ After observing s , the seller makes a take-it-or-leave-it offer (p, x) . Finally, the buyer accepts or rejects. The equilibrium concept is the Perfect Bayesian Nash equilibrium. Without loss of generality, we assume the buyer accepts any offer that yields positive utility.

prefers to implement the project and minimize the budget. In this case, the local manager has incentives to communicate strategically in order to persuade the CEO to increase the division budget.

⁹The results trivially extend for the case where $\tilde{U}(p, x; \theta) := v(1 - \|x, \theta\|) - p$ for any $v \in \mathbb{R}_{++}$.

¹⁰The Salop circular model facilitates the algebra to find the equilibrium under ID.

¹¹Under ID, the buyer chooses a cumulative distribution F , but under CT the cumulative distribution F arises from players' beliefs in the equilibrium.

3 Strategic Information Transmission (CT)

We first show that our model fits into the Strategic Information Transmission environment (Crawford and Sobel, 1982). The seller's offer comprises a product location x , defining the welfare loss $\|\theta, x\|$, and a price p , defining how to share the surplus when there is trade. If the buyer perfectly communicates θ , the seller will offer $(p, x) = (1, \theta)$, guaranteeing trade and fully appropriating the (maximum) welfare. If the buyer communicates nothing about θ , the seller offers, for instance, $(p, x) = (0.5, 1)$; then there is a probability of no trade equal to $1/2$, reducing welfare, but allowing the buyer enjoys positive expected surplus equal to $1/8$. As no trade makes both the buyer and the seller strictly worse off, the objective functions are partially aligned. Thus, some (but probably not all) information can be transmitted through *Cheap Talk* (CT).

We follow the literature on Cheap Talk that proves that there exists a partition of $[0, 2]$ that forms an equilibrium of the communication game. Figure 1 shows examples of equilibria with partitions of $n = 2, 3, 4$. Actually, Proposition 1 shows that any partition of the set $[0, 2]$ in connected intervals of equal length can be a part of an equilibrium.

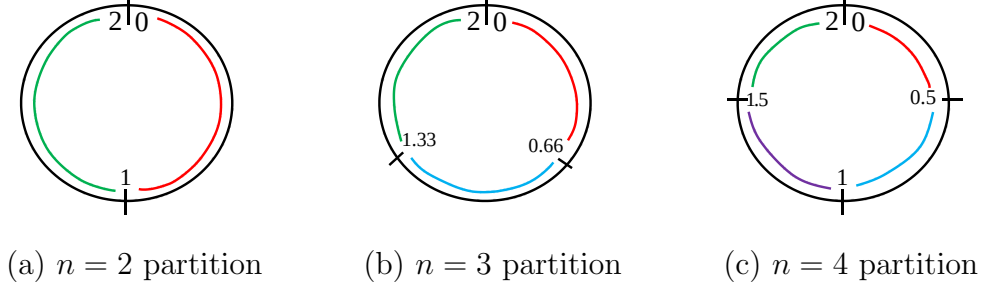


Figure 1: Examples of equilibria for different partitions.

Proposition 1. *For any $n \in \mathbf{N}$, there exists an equilibrium with n -partition subsets of equal length of $[0, 2]$ of the form $\left[(j-1)\frac{2}{n}, j\frac{2}{n}\right)$ for each $j = 1, \dots, n$ (last interval is closed) where,*

1. *The buyer's signaling rule is defined by,*

$$F\left(s \mid \theta \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right)\right) = \begin{cases} 0 & \text{if } s < (j-1)\frac{2}{n}, \\ \frac{n}{2} \left(s - (j-1)\frac{2}{n}\right) & \text{if } s \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right), \\ 1 & \text{if } s \geq j\frac{2}{n}. \end{cases}$$

2. The seller's beliefs are defined by

$$H\left(\theta \mid s \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right)\right) = \begin{cases} 0 & \text{if } \theta < (j-1)\frac{2}{n}, \\ \frac{n}{2}(\theta - (j-1)\frac{2}{n}) & \text{if } \theta \in \left[(j-1)\frac{2}{n}, j\frac{2}{n}\right), \\ 1 & \text{if } \theta \geq j\frac{2}{n}. \end{cases}$$

3. Price and location are defined by $p(s) = 1 - \frac{1}{n}$ and $x(s) = 0.5((j-1)\frac{2}{n} + j\frac{2}{n}) = \frac{2j-1}{n}$ given that s belongs the j -th subset.

Hence there are infinitely many equilibria.¹² Our comparison between CT and ID holds for all informative equilibria, i.e., except the pure babbling equilibrium. However, in order to make a clean comparison, we concentrate in the equilibria that satisfy two conditions: 1) be Pareto optimal; 2) be Pareto superior than the no communication case. Then, we eliminate those equilibria that are Pareto inferior or that are dominated by saying nothing for at least one of the players (or not showing up and sending a mute or uninformed intermediary).

Lemma 2. *The cheap talk equilibria that are Pareto optimal and that are better off for both player compared to the no communication case are those equilibria with partitions of $n = 2, 3, 4$ which actions and beliefs are defined according to Proposition 1.*

A babbling equilibrium does not satisfy this refinement. The difference among these equilibria is the total surplus generated and how it is shared between the seller and the buyer. Table 1 shows the values of the price, profits, buyer surplus, welfare, and probability of trade for each n -partition with $n = 1, 2, 3, 4$. A simple comparison shows that $E[U](n)$ decreases in $n > 2$ and that $E[U](1) > E[U](n)$ for $n \geq 5$.

On the other hand, there is a trade-off between generation and appropriation when comparing equilibria with partitions $n = 2, 3$, and 4. Having more partitions increases welfare and the seller's ability to appropriate it. The seller appropriates the welfare increased and, additionally, part of the buyer surplus when increasing the number of partitions. Consequently, objective functions for equilibria with $n = 2, 3, 4$ partitions are perfectly misaligned and, ex-ante, there is no unique criteria to select among them. So our comparison will have these three types of equilibria as a benchmark.

4 Strategic Information Disclosure (ID)

Under Information Disclosure (ID), the buyer announces and commits to a signal s of the form $F(s|\theta) : [0, 2] \rightarrow [0, 1]$, where F may change with θ . Note that, using this

¹²Even with exactly the same number of n -partition there are infinite equilibria. Notice that a 2-partition for an equilibrium can be either $\{[0, 1), [1, 2)\}$ or $\{[0.5, 1.5), [0, 0.5) \cup [1.5, 2]\}$, or any partition of this kind.

Table 1: Price, profits, buyer surplus, welfare, and probability of trade for Cheap Talk equilibria for a n -partition equilibria.

partition n	price p	profits $E[\Pi]$	buyer surplus $E[U]$	welfare $E[W]$	prob. of trade $Pr(v \geq p)$
1	0.500	0.250	0.125	0.375	0.5
2	0.500	0.500	0.250	0.750	1
3	0.666	0.666	0.166	0.833	1
4	0.750	0.750	0.125	0.875	1

signal technology, the buyer can trivially replicate the distribution corresponding to any CT equilibrium. Consequently, the buyer must be better off under ID. Additionally, it is straightforward to see that there are signal structures under ID that Pareto dominate those under CT.¹³ It is not clear, however, that, in effect, the buyer chooses among these Pareto superior signals, increasing welfare and/or seller payoffs.

Definition 3. *An equilibrium in the ID game is characterized by a signal structure F , seller's posterior H (beliefs) about θ , and offers $(p(H), x(H))$ such that: 1) H is derived by Bayes' Rule whenever possible; 2) Each $(p(H), x(H))$ maximize seller profit $E[\Pi](H)$; and 3) F maximizes buyer surplus conditioning on seller's best reply $(p(H), x(H))$.*

Following Kamenica and Gentzkow (2011), the buyer can manipulate seller's posterior H about θ as long as it is *Bayes Plausible*. As stated in Definition 3, the buyer's problem is to find a signal structure F to maximize his expected surplus conditioning on seller's best response. After receiving a realization s from F , the seller calculates the posterior H about buyer's type θ . Our setup facilitates the solution of the problem, as it allows the buyer to design an arbitrary signal distribution F to replicate any posterior H using Bayes rule.

We solve buyer's problem of maximizing his expected surplus choosing H anticipating seller's best reply $(p(H), x(H))$, and then we show how to implement this optimal H (being Bayes Plausible). Seller's best reply is defined by

$$(p(H), x(H)) \in \arg \max_{(p,x)} \int_0^2 p I(\theta, p, x) dH(\theta), \quad (2)$$

where $I(\theta, p, x) = 1$ if $1 - \|\theta, x\| - p \geq 0$ and 0 otherwise. That is, the seller profit is p if there is trade, i.e., if $I(\theta, p, x) = 1$.

¹³Comparing with a Cheap Talk equilibrium with $n = 3$ (see Table 1), a signal $s := (\theta - 0.3, \theta - 0.15, \theta, \theta + 0.15, \theta + 0.3)$ with probabilities $q := (0.1, 0.08, 0.64, 0.08, 0.1)$, with seller's strategies $(x, p) = (s, 0.7)$, would generate a buyer surplus of 0.216, a seller's profit of 0.7, and, thus, a welfare of 0.916.

Conditioning on seller's best replies $(p(H), x(H))$ from Condition (2), the buyer chooses H to maximize his expected surplus

$$\max_H \int_0^2 \max \left\{ 0, 1 - \|\theta, x(H)\| - p(H) \right\} dH(\theta). \quad (3)$$

The buyer enjoys utility $U(p, x; \theta) = 1 - \|\theta, x\| - p$ if there is trade and zero otherwise.

Assuming that a solution exists (which is then confirmed) this problem can be simplified. Suppose (p_0, x_0) is the best response to H , then there is trade for every buyer type $\theta \in [x_0 - (1 - p_0), x_0 + (1 - p_0)]$. Assuming, wlog, $[x_0 - (1 - p_0), x_0 + (1 - p_0)] \subset [0, 2]$,¹⁴ the buyer's problem can be written as

$$\begin{aligned} \max_H E[U] &= (1 - p_0) \left[H(x_0 + (1 - p_0)) - H(x_0 - (1 - p_0)) \right], \\ &\quad - \int_{x_0 - (1 - p_0)}^{x_0} (x_0 - \theta) dH - \int_{x_0}^{x_0 + (1 - p_0)} (\theta - x_0) dH, \\ \text{s.t. } (p_0, x_0) &\in \arg \max_{(p, x)} p \left[H(x + (1 - p)) - H(x - (1 - p)) \right]. \end{aligned} \quad (4)$$

The first term in $E[U]$ represents the maximum buyer surplus of buying a product at a price p_0 . The second and third terms represent the loss incurred when the buyer buys a product which does not fit with his ideal one. The seller payoff is the price multiply by the probability of trade. Given this representation, the next result is direct.

Lemma 4. *If H with the best response (p_0, x_0) solves Problem 4, then there is trade with probability one.*

In Lemma 4 we prove that situations with no trade decreases both players payoff. The buyer can manipulate H avoiding those cases and increasing both players payoff. Now we define the posterior that maximizes buyer surplus when implementing a best reply (p_0, x_0) .

Proposition 5. *If the buyer wants to implement (p_0, x_0) as seller's best response, then the posterior H that maximizes his surplus $E[U]$ is,*

$$H^*(\theta) = \begin{cases} 0 & \text{if } \theta \in [x_0 - 1, x_0 - (1 - p_0)), \\ \frac{1 - p_0 + \theta - x_0}{1 + p_0 + \theta - x_0} & \text{if } \theta \in [x_0 - (1 - p_0), x_0), \\ \frac{2p_0}{1 + p_0 - \theta + x_0} & \text{if } \theta \in [x_0, x_0 + (1 - p_0)], \text{ and} \\ 1 & \text{if } \theta \in [x_0 + (1 - p_0), x_0 + 1]. \end{cases} \quad (5)$$

¹⁴We can always redefine the domain from a point x_0 as $\theta \in [x_0 - 1, x_0 + 1]$.

Having the optimal H^* to implement (p_0, x_0) , the buyer's problem is easy to solve. Using H^* , the buyer surplus can be represented as a function only of p_0 as follows

$$E[U](p_0) = -(1 - p_0) + 4p_0 \ln \left(\frac{1 + p_0}{2p_0} \right), \quad (6)$$

which is a continuous, differentiable, and concave function for $p_0 \in (0, 1)$. From the first order condition we get $4 \ln \left(\frac{1+p_0}{2p_0} \right) = \frac{3-p_0}{1+p_0}$, which is uniquely solved by $p_0 \cong 0.487657$. Consequently, replacing p_0 in Equation (6) we calculate buyer surplus $E[U] \cong 0.311$.

Next, we characterize the signal distribution F that implements H^*

Proposition 6. *To implement the posterior H^* the buyer sends a signal s distributed according to,*

$$F^*(s | \theta) = \begin{cases} 0 & \text{if } s \in [\theta - 1, \theta - (1 - p_0)), \\ \frac{1-p_0+s-\theta}{1+p_0+s-\theta} & \text{if } s \in [\theta - (1 - p_0), \theta), \\ \frac{2p_0}{1+p_0-s+\theta} & \text{if } s \in [\theta, \theta + (1 - p_0)], \text{ and} \\ 1 & \text{if } s \in [\theta + (1 - p_0), \theta + 1], \end{cases} \quad (7)$$

A realization s of F^* generates the posterior $H^*(\theta|s, F^*)$ according to Equation 5 where $x_0 = s$. The seller's best reply is defined by a price $p(H^*) \cong 0.487657$ and a product location $x(H^*) = s$. Notice that the signal can be represented by $s = \theta + \varepsilon$ where ε represents the signal deviation respect to buyer's type, independently of his realization.

Figure 2.a represents the posterior H (normalizing $x_0 = 0$) or the signal distribution F (normalizing $\theta = 0$). Figure 2.b shows the distribution of valuations $v := 1 - \|\theta, x_0\|$ in the solution $x_0 = s$. The cumulative distribution of the signal is antisymmetric at $1/2$ around θ (i.e., the mass is symmetrically distributed around θ), continuous except in the true θ where there is a jump, and its slope increases for values that are more distant to θ . The signal reveals the true location with high probability (mass-point). However, when the signal is wrong, it is more likely that the signal is closer to the limits of the domain (closer to $\theta - (1 - p_0)$ or $\theta + (1 - p_0)$) than closer to θ . The buyer uses this signal shape to persuade the seller to reduce the price at the (likely) cost of reducing product attractiveness.

A simple comparison between buyer's surplus under ID, $E[U] \cong 0.311$, with respect to any CT, $E[U] = \{0.25, 0.166, 0.125\}$, explains why the buyer prefers ID to CT. Additionally, the seller profits show the opposite result, as she enjoys higher profits under any CT, $\{0.50, 0.66, 0.75\}$, than under ID 0.487. We have pointed out situations where the receiver (the seller) chooses the communication environment. A more general result indicates that depending which of them chooses the communication setup we will have one environment or the other.

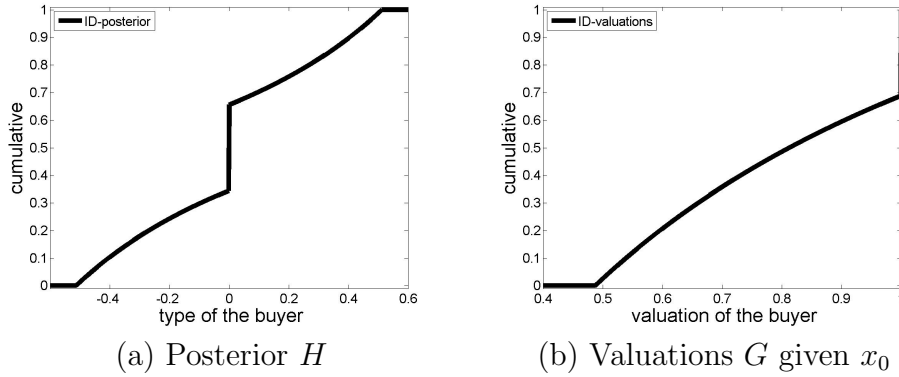


Figure 2: Cumulative distribution under ID normalizing $x_0 = 0$.

Finally, as pointed out at the beginning of this section, there always exists an ID communication that dominates a CT equilibrium. Consequently, a next step would be to study whether incorporating restrictions to the ID signals makes this environment superior to CT. Research on this ground is welcome.

5 Welfare

To make a comparison we define the welfare function. Independent of the distribution that generates the posterior, the welfare $E[W] = E[U] + E[\Pi]$ as a function of posterior H and best reply (p_0, x_0) is defined by¹⁵

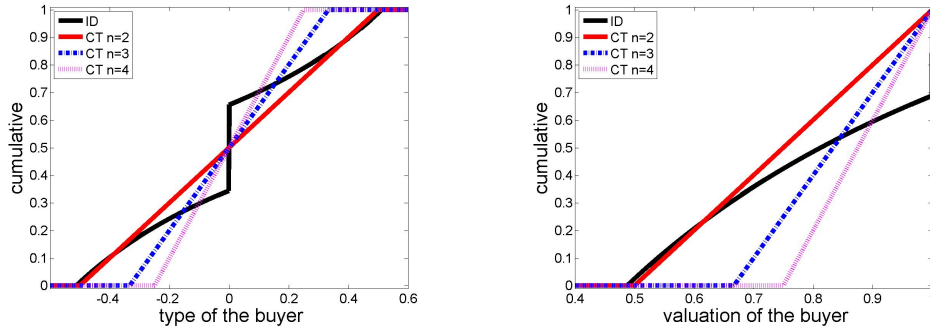
$$E[W](p_0, x_0, H) := 1 - \int_{x_0 - (1-p_0)}^{x_0} H(\theta) d\theta - \int_{x_0}^{x_0 + (1-p_0)} [1 - H(\theta)] d\theta. \quad (8)$$

If we define buyer valuation $v := 1 - \|\theta, x_0\|$ where $v \sim G$ (G depends on H and x_0), then the welfare function is defined by

$$E[W](p_0, G) := 1 - \int_{p_0}^1 G(v) dv. \quad (9)$$

A graphical comparison between CT equilibria and ID equilibria with cumulatives H and G is represented in Figures 3.a and 3.b, respectively. Recall that p_0 (and profits) are equal to 0.500, 0.666, and 0.750 for CT with $n = 2, 3$, and 4 partitions, respectively, and 0.487657 for ID.

¹⁵This representation is feasible if H has finitely many jumps (Cramer, 1946).



(a) H^* with $CT(n = 2, 3, 4)$ and ID (b) G^* with $CT(n = 2, 3, 4)$ and ID

Figure 3: Cumulatives of posterior (H^*) and valuations (G^*), normalizing $x_0 = 0$.

The values calculated are $E[W] \cong 0.798867$ for ID and $E[W] = \{0.75, 0.833, 0.875\}$ for CT of $n = 2, 3, 4$, respectively. In two out of three cases the CT overcomes ID in terms of welfare. CT will prove to be even more preferable if, eventually, Disclosure requires additional costs.

6 Comparison and conclusion

We have shown several results. First, the buyer trivially prefers ID over CT . Second, there is trade with probability 1 in any informative equilibria and a welfare loss arises when actual product's design does not fit the buyer's ideal one. Third, the seller's payoff is higher with CT than with ID (i.e., $\{0.5, 0.66, 0.75\} > 0.487$). Finally, and more important, the ID reduces total welfare in two out of three cases (i.e., $0.750 < 0.799 < \{0.833, 0.875\}$).

This analysis reveals that CT can result as the optimal communication structure when there are incomplete contracts. Consequently, restricting the set of signals may improve the seller profit and welfare. As we assume that the seller has the bargaining power, he may also choose the communication environment but not the strategic behavior. For instance, consider situations where the receiver is a long-run player (e.g., an architect, a designer, or a bank) who interacts with a short-run sender (e.g., buyers or borrowers).

Empirical evidence in the use of Cheap Talk and Disclosure (like certifications) is mixed. For instance, before offering a financial contract, a lender (seller) may require a borrower (buyer) to certify his financial records in order to show financial responsibility. This evidence suggests that, under some constraints over signals, certifications are used as a way to disclose information. Consequently, more research is needed to understand the constraints required over the set of ID signals to be superior to CT .

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A Appendix: Main Results

Proof of Proposition 1. This proof is direct from Crawford and Sobel (1982). $\square$

Proof of Lemma 2. $E[U](1) = \frac{1}{8}$ and $E[U](n) = \frac{1}{2n}$ for $n \geq 2$. Then $E[U](n) \geq E[U](1)$, if $n \leq 4$. $\square$

Proof of Lemma 4. Suppose not, then there exists another $\hat{H}$ with the same best response (p_0, x_0) such that guarantees trade with probability one, relaxing the constraint, and increases $E[U]$. Thus, H could not be a solution. $\square$

Proof of Proposition 5. If the buyer wants to implement (p_0, x_0) , then H must provide the maximum buyer surplus and it must survive to any deviation $(\hat{p}, \hat{x})$. In particular we first check deviations $(\hat{p}_0, \hat{x}_0) = (p_0 + |a|, x_0 + a)$ for $a \in [-\frac{1-p_0}{2}, \frac{1-p_0}{2}]$, and then we prove that these deviations are the relevant ones.

Given, for instance, a deviation $(\hat{p}_0, \hat{x}_0) = (p_0 + a, x_0 + a)$ with $a > 0$, all buyer types $\in [x_0 - (1 - p_0) + 2a, x_0 + (1 - p_0)]$ buy the product. As the profit with no deviation is $E[\Pi] = p_0$ (there is trade with probability one), a deviation $(p_0 + a, x_0 + a)$ with $a > 0$ does not survive if

$$p_0 \geq (p_0 + a)[1 - H^-(x_0 + 2a - (1 - p_0))], \text{ or}$$

$$H^-(\theta = x_0 + 2a - (1 - p_0)) \geq \frac{a}{a + p_0}.$$

H^- represents the limit from the left.¹⁶

Replacing $a = \frac{1-p_0+\theta-x_0}{2}$ half of the H^* is defined. Deviations $(p_0 + |a|, x_0 + a)$ with $a < 0$ does not survive if

$$p_0 \geq (p_0 - a)H(x_0 + 2a + (1 - p_0)), \text{ or}$$

$$H(\theta = x_0 + 2a + (1 - p_0)) \leq \frac{p_0}{p_0 - a}.$$

Replacing $a = \frac{-1+p_0+\theta-x_0}{2}$ the other half of H^* is defined.

It is easy to verify that given H^* and a deviation $x_0 + a$, the seller maximizes profit at $p = p_0 + |a|$. For instance, for $a > 0$ the price has 3 relevant segments: 1) $p > 1 - a$; 2) $1 - a \geq p \geq p_0 + a$; and 3) $p_0 + a > p$. Calculating the profit function, the reader can verify that $\frac{\partial \Pi}{\partial p}(p < p_0 + a) > 0$ and $\frac{\partial \Pi}{\partial p}(p > p_0 + a) < 0$, then $p = p_0 + a$. $\square$

Proof of Proposition 6. It is direct. $\square$

¹⁶Cumulative distributions are, by definition, continuous from the right. But intuitively, a buyer with type $\theta = x_0 + 2a - (1 - p_0) < x_0$ (who is indifferent between buying or not) should buy. We use the limit from the left to represent this situation when H has a jump at $\theta = x_0 + 2a - (1 - p_0)$. Note that this is not a problem for rightward deviations (when $a < 0$).